

Superconducting Joint and Persistence Switch Prototype

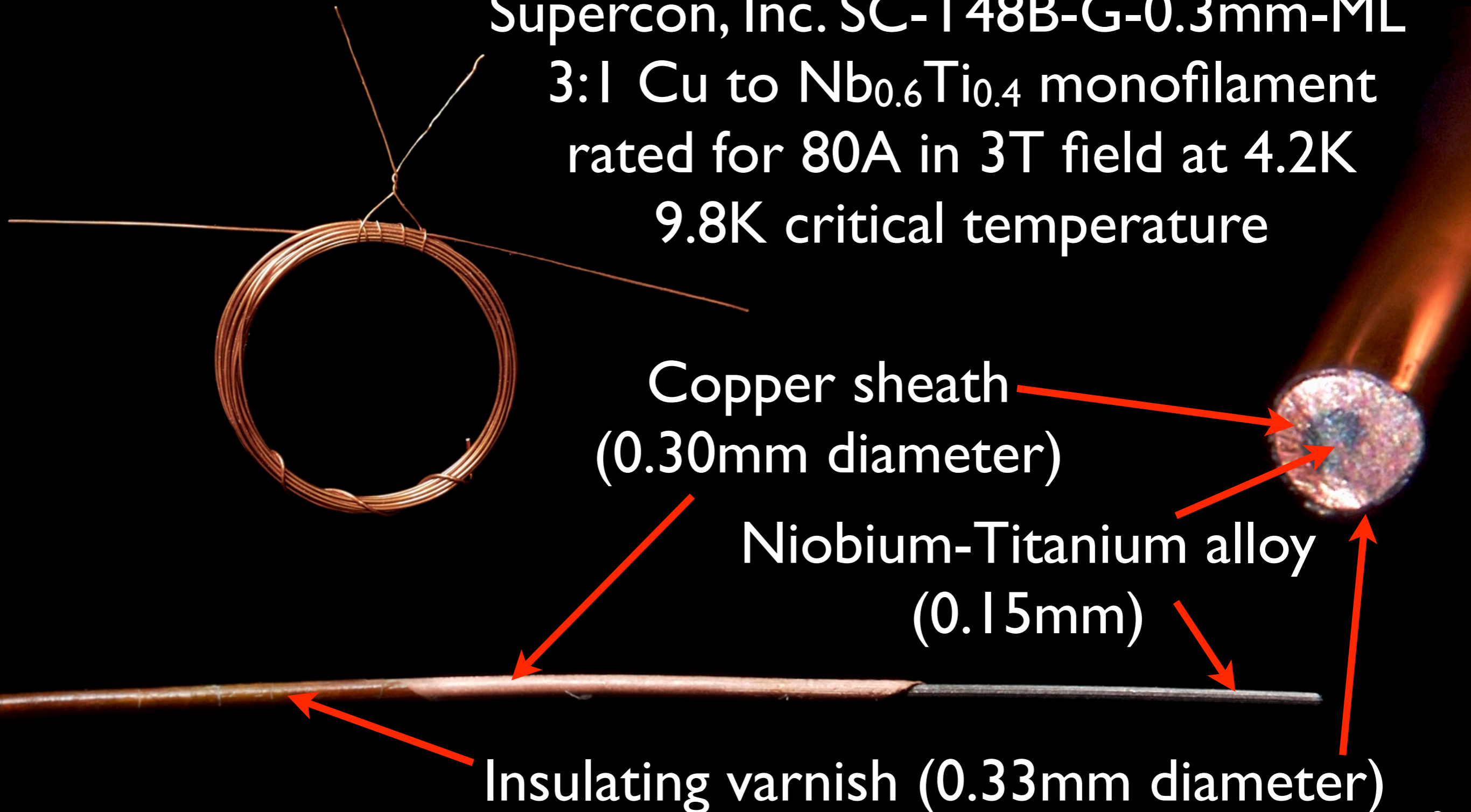
Michael Mendenhall (Caltech)
nEDM Collaboration Meeting, February 10, 2008

Purpose

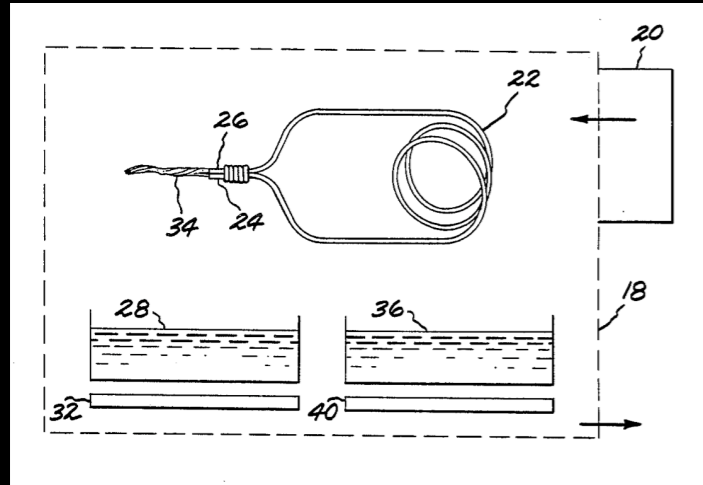
- Make a superconducting joint between ends of copper-clad NbTi wire
 - Low field, low current operation
- Make a heater switch
 - Easy to build
 - Robust

Wire

Supercon, Inc. SC-T48B-G-0.3mm-ML
3:1 Cu to Nb_{0.6}Ti_{0.4} monofilament
rated for 80A in 3T field at 4.2K
9.8K critical temperature



Superconducting joint



info from US Patent 4,584,547
(Roy F.Thornton, General Electric, 1986)

Where high current capacity is not needed, a wide range of parameters produces a working joint:

- Solder between 5% and 98% Pb, rest Bi
- Works at any temperature above melting point of solder
- Joint can be made in air

Solder



Cerrobase casting alloy
55.5% Bismuth
44.5% Lead

Joint forming process



Joint forming process

- Scrape off insulation



Joint forming process



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- Dissolve away copper in 300°C molten tin bath (30 minutes)



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- Replace tin with Pb-Bi solder in 300°C bath (30 minutes)



Joint forming process



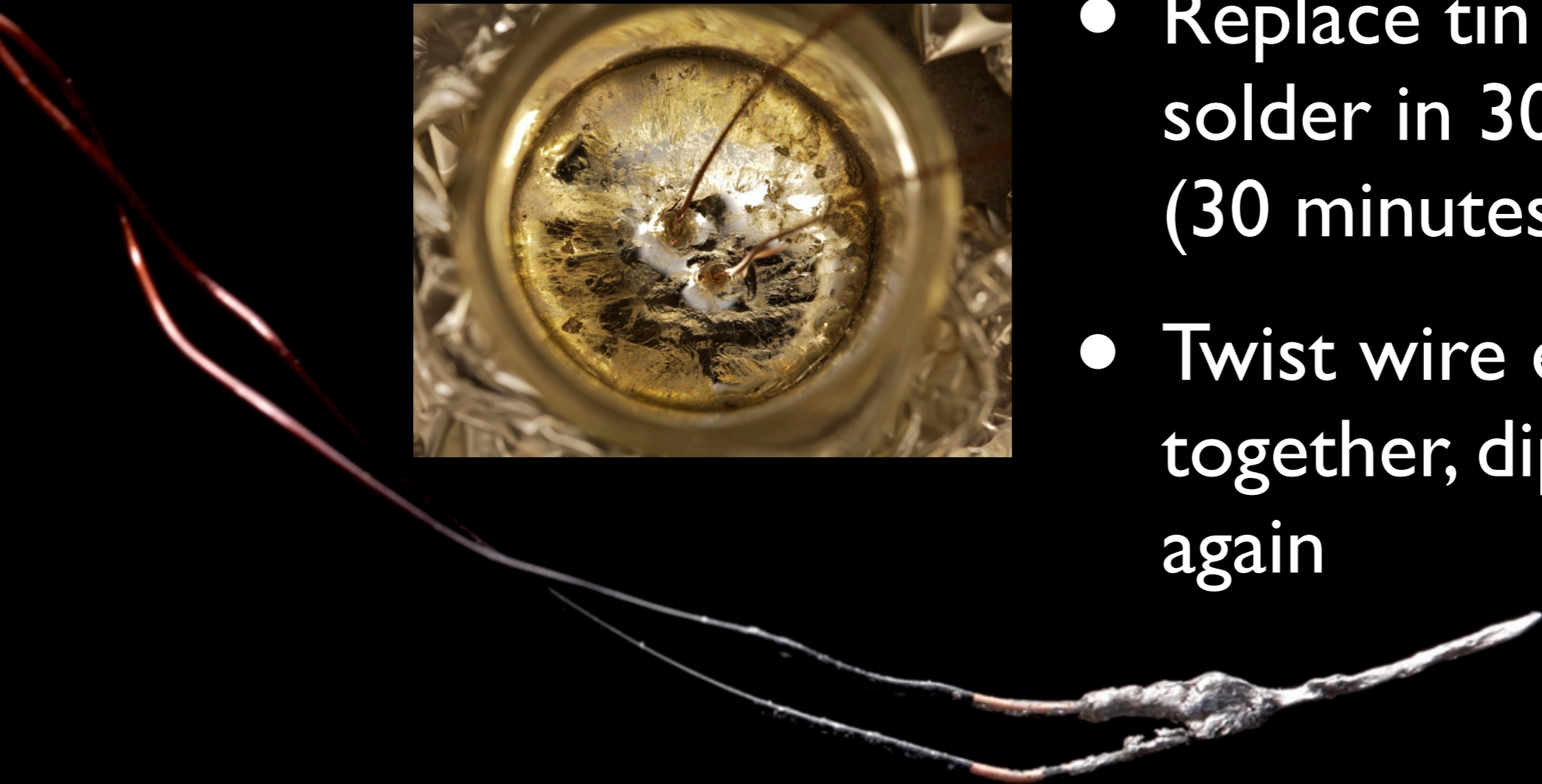
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- Replace tin with Pb-Bi solder in 300°C bath (30 minutes)
- Twist wire ends together, dip in Pb-Bi again




Joint forming process



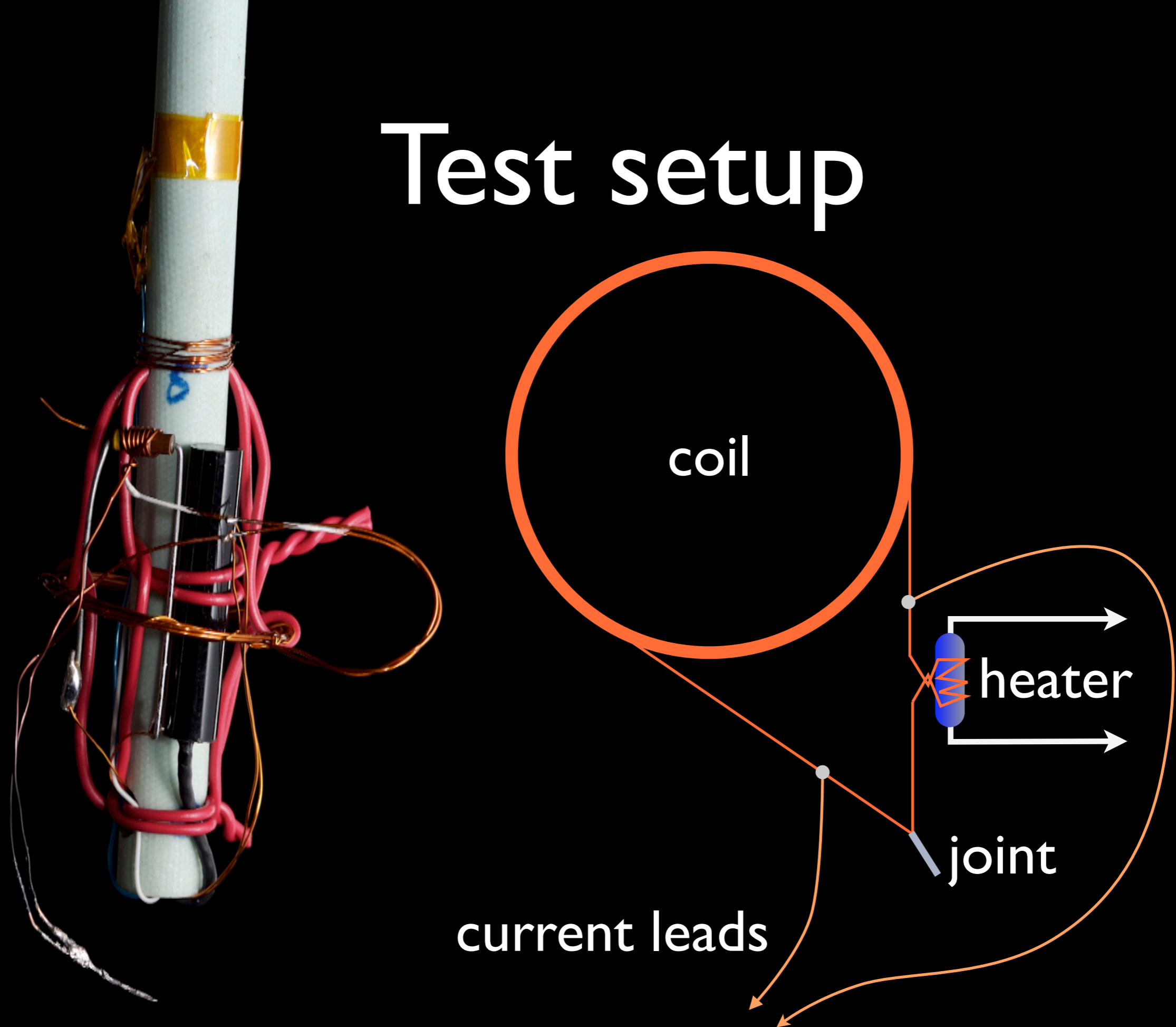
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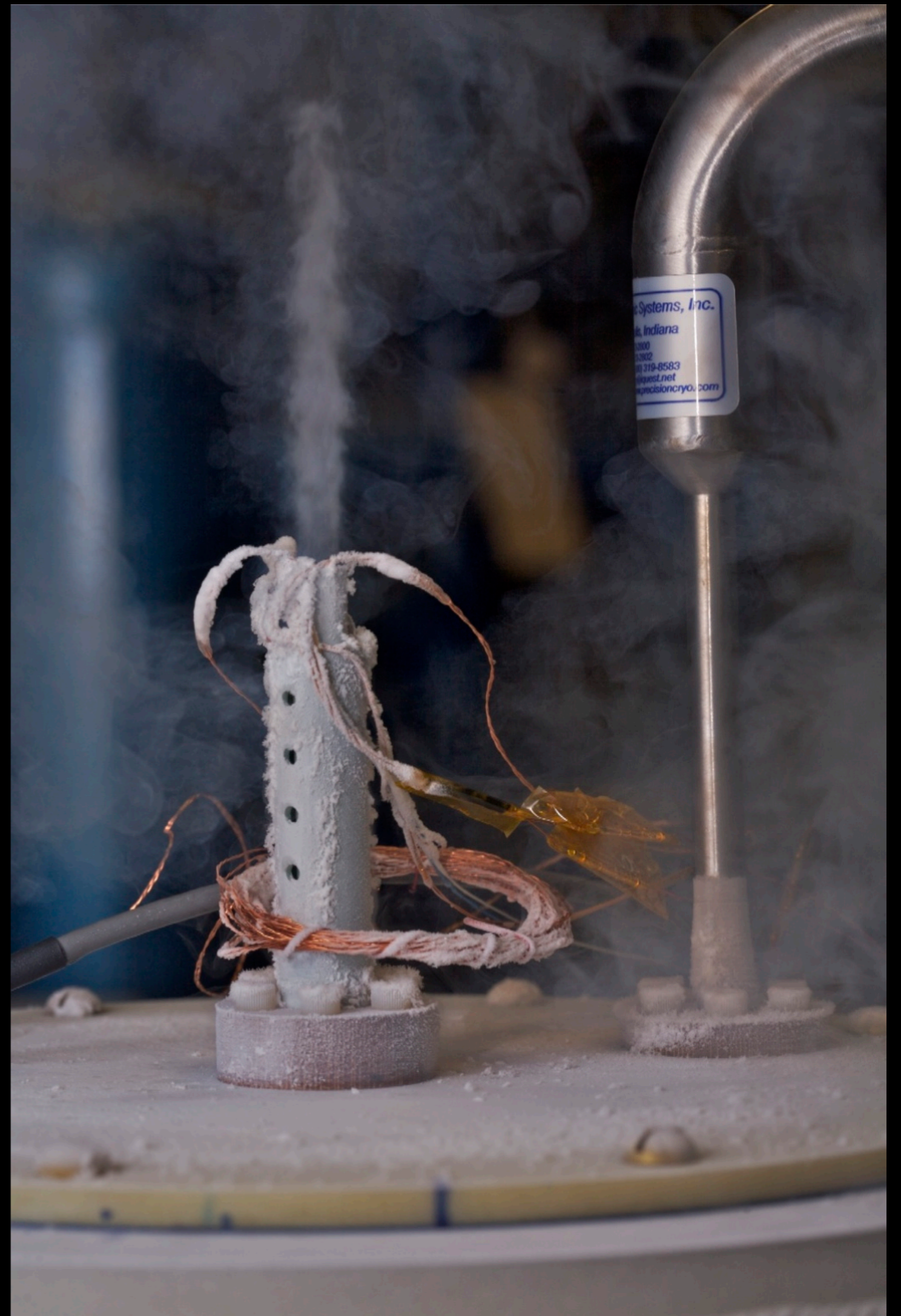
Heater switch

- 
- 1/4 Watt, Carbon-composition resistor
 - Convenient, pre-packaged heating element
 - Resistance approximately doubles at 4K

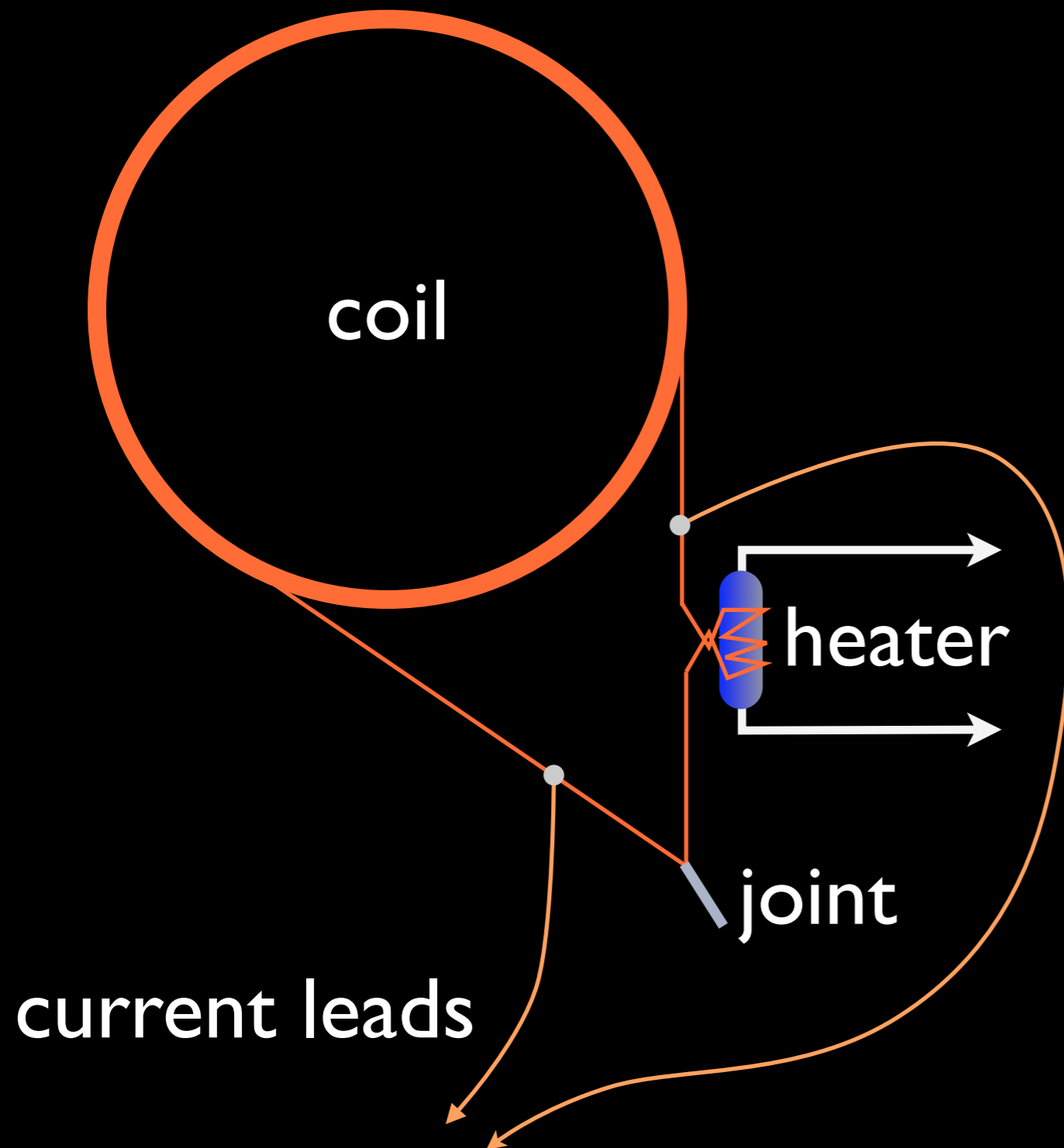
Test setup



Test setup

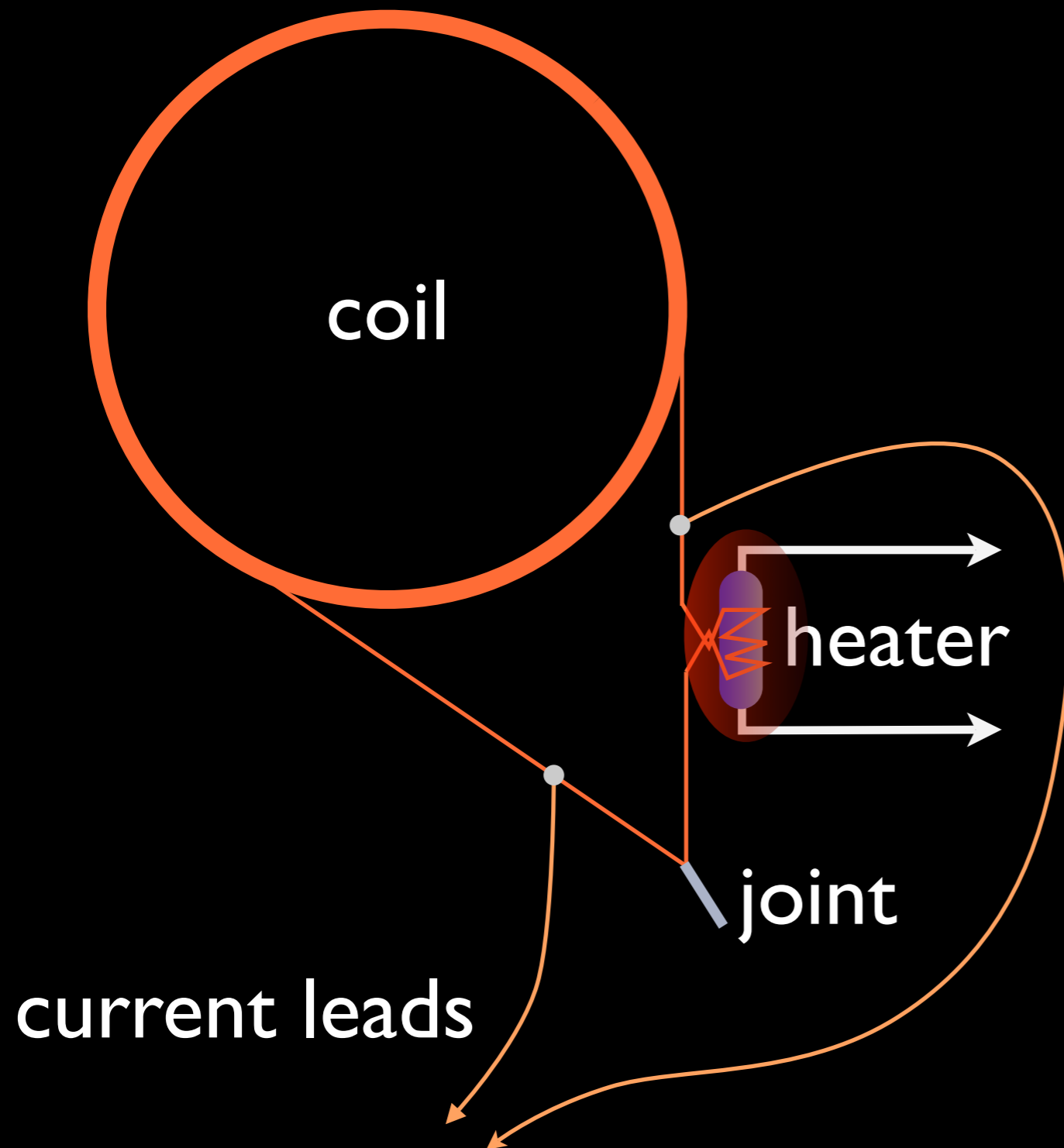


Procedure

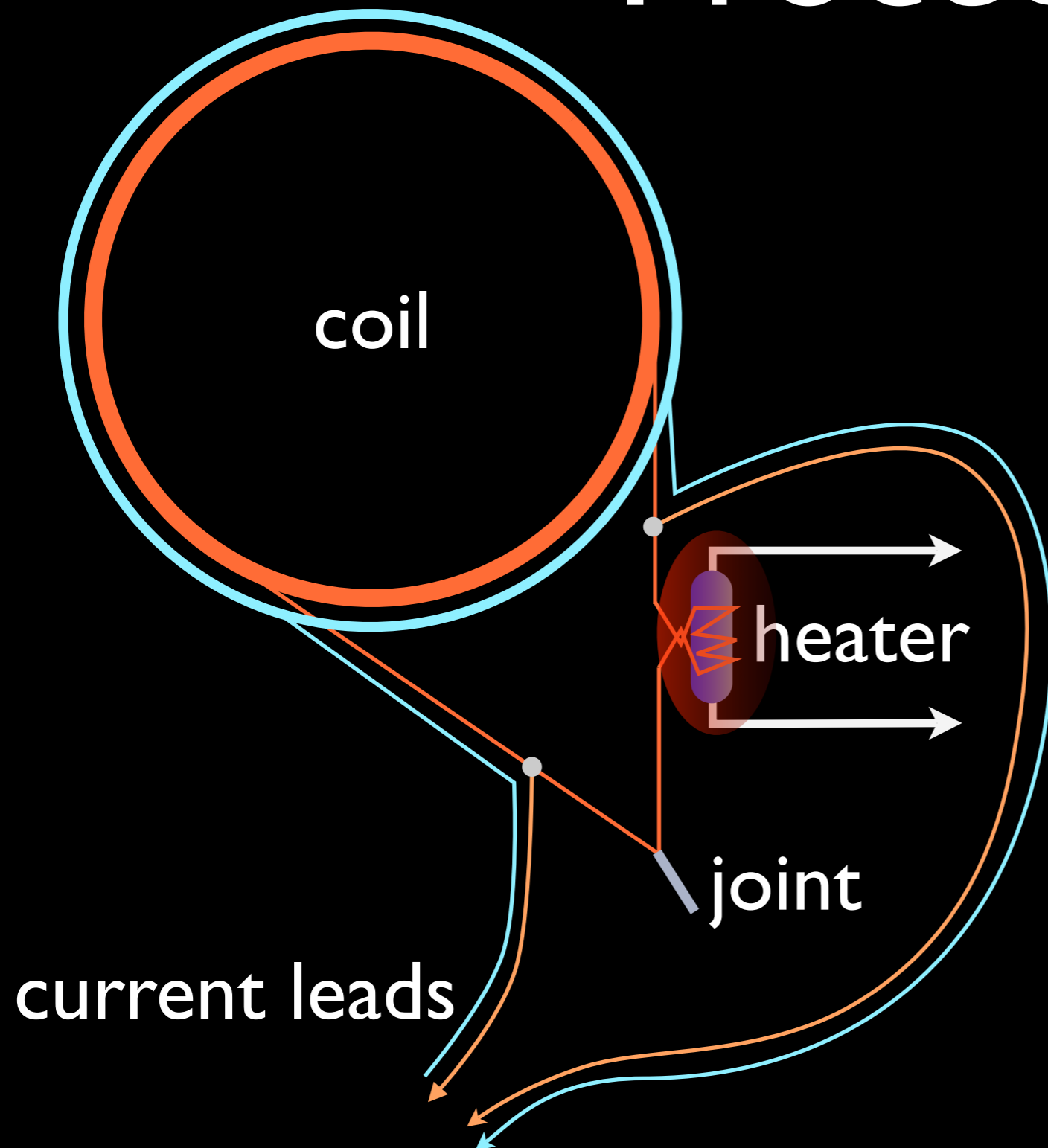


Procedure

- turn on heater

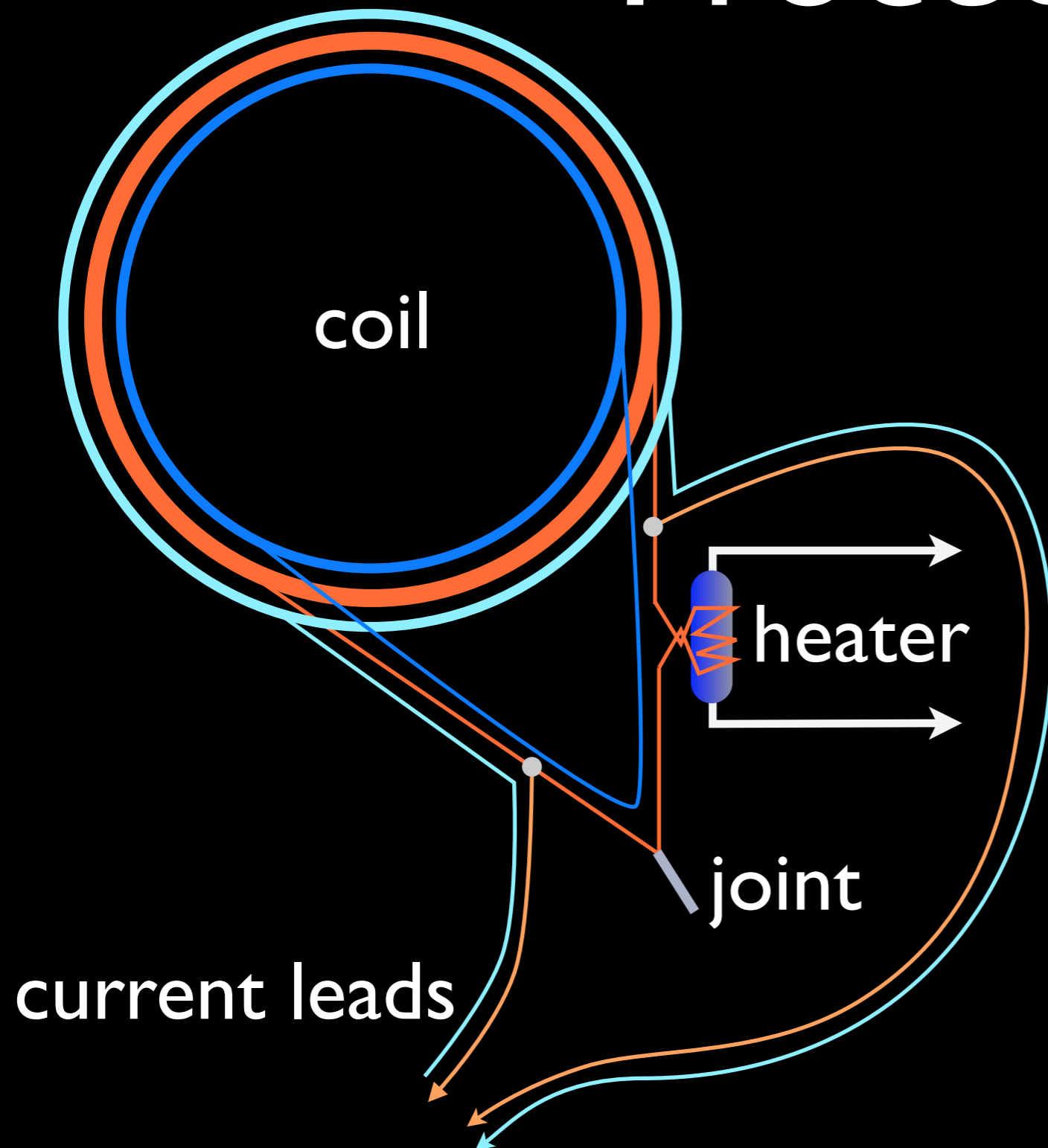


Procedure



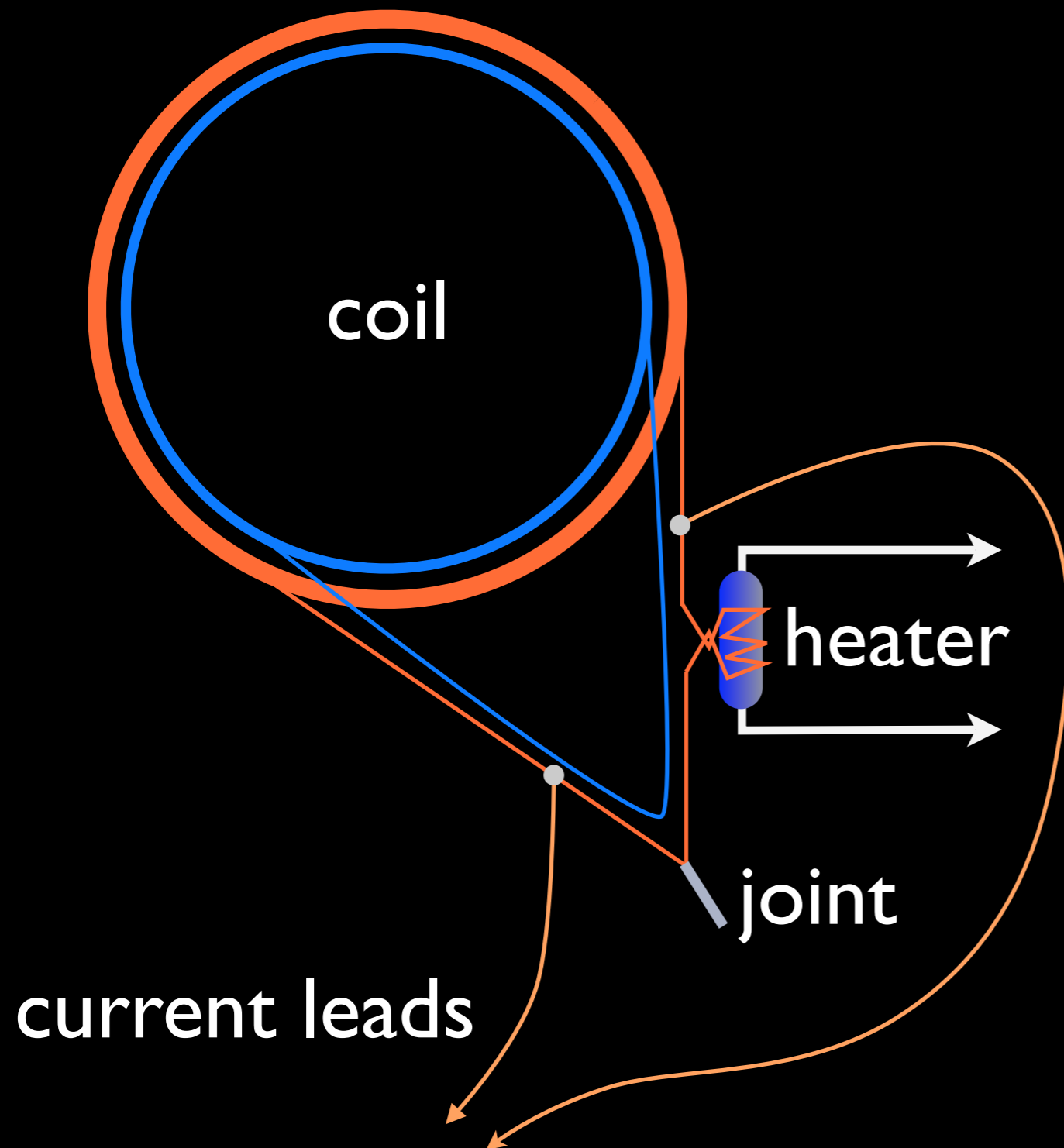
- turn on heater
- apply external current

Procedure



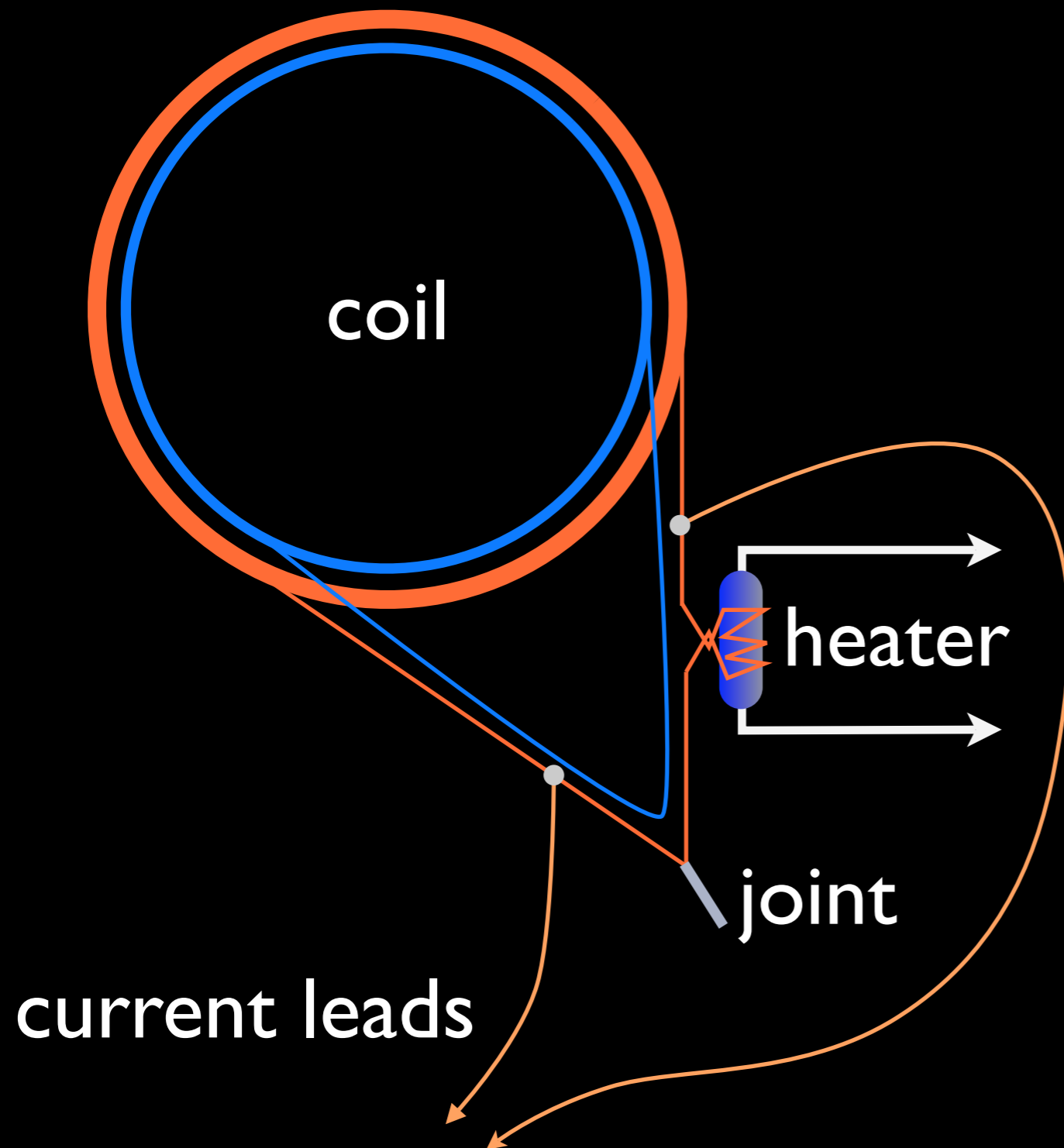
- turn on heater
- apply external current
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Procedure



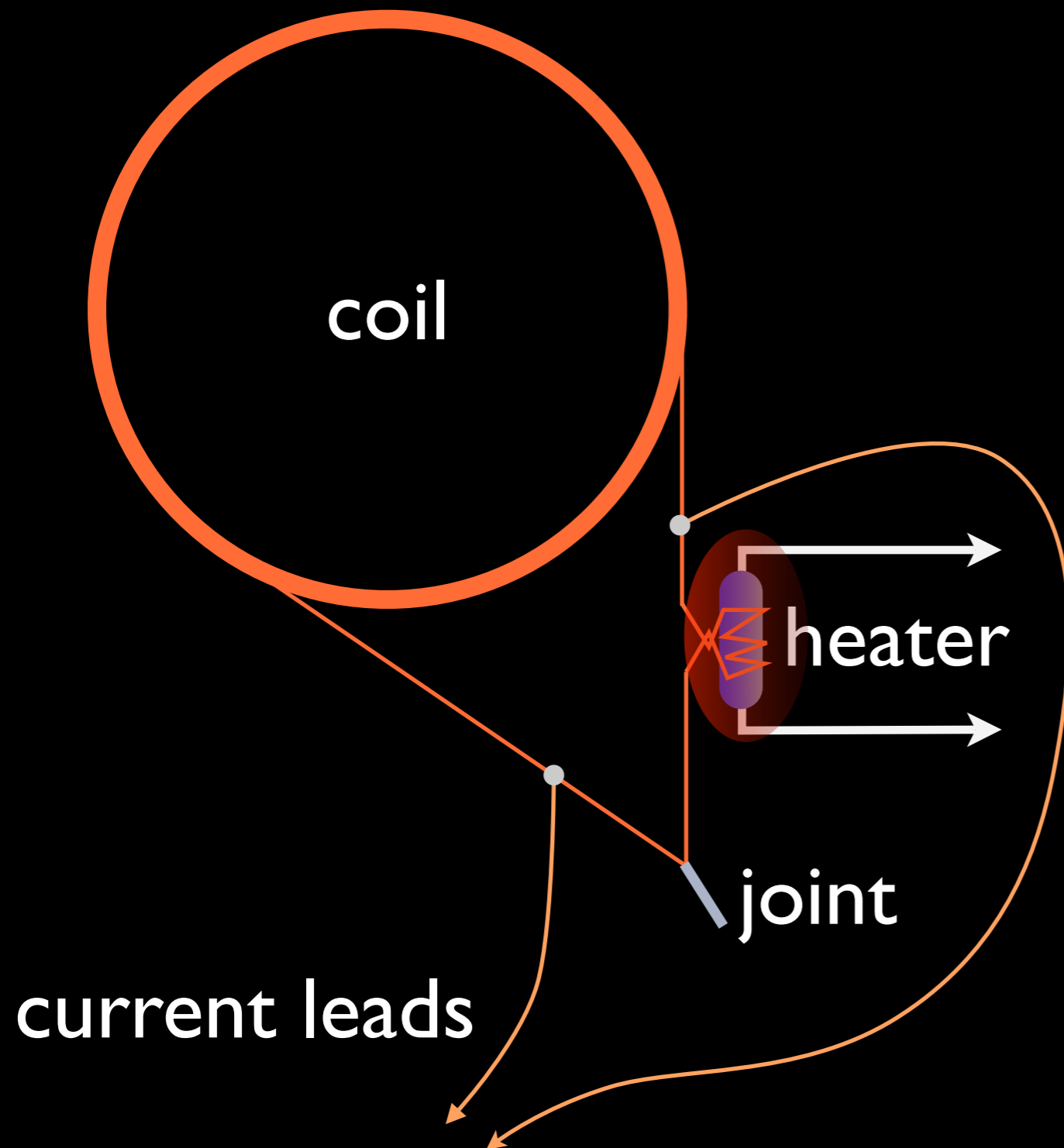
- turn on heater
- apply external current
- turn off heater
- turn off current supply

Procedure



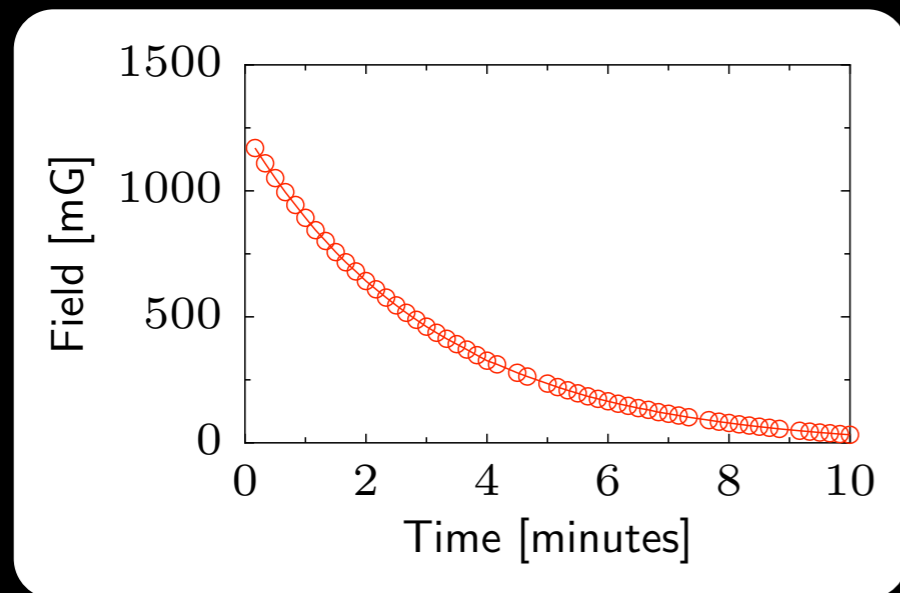
- turn on heater
- apply external current
- turn off heater
- turn off current supply
- persistence!

Procedure



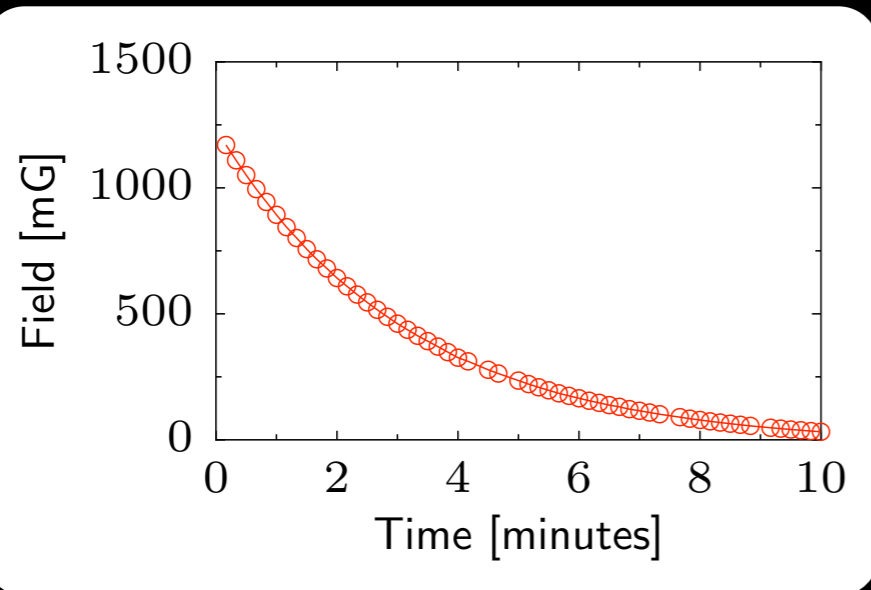
- turn on heater
- apply external current
- turn off heater
- turn off current supply
- persistence!
- turn on heater

Results

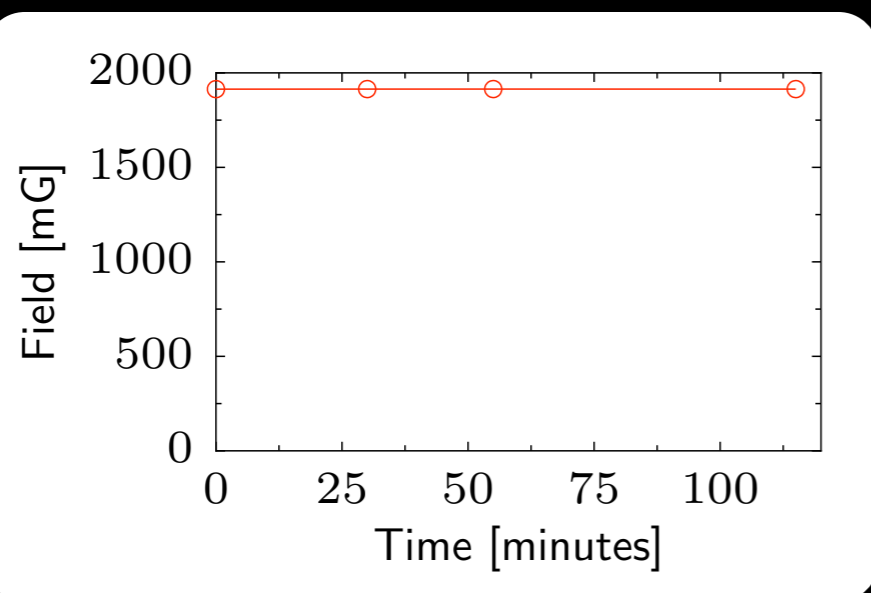


Non-superconducting tin joint
Lifetime: 3 minutes

Results



Non-superconducting tin joint
Lifetime: 3 minutes



Lead-Bismuth joint
Lifetime: > 1 year
(probably ∞)

Conclusion

A functional superconducting joint and persistence switch heater can be made by the methods demonstrated using readily available materials and equipment.